The use of Seakleen® as a treatment for Ballast water.

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The Baltimore Harbor Ballast Water Treatment Project is the largest program of its kind in the U.S. and seeks to develop and test the efficacy of ballast water treatment technologies at the full scale, shipboard level. Since 2000 the project has received major funding from Maryland Port Administration and the National Oceanic and Atmospheric Administration (NOAA), National Sea Grant Ballast Water Program. It builds on a long-running laboratory-based program funded by NOAA since 1980 investigating the problems associated with the spread of aquatic nuisance species and methods of control. Recent, shipboard studies have been carried out aboard vessels of the U.S. reserve fleet under the auspices of the U.S. Maritime Administration (MARAD).

Thus far, treatments tested have included physical particulate separation, UV irradiation and biocides. Initial full-scale experiments were conducted aboard the U.S.S. *Cape May* in Baltimore Harbor in 2001. Seakleen® was developed in part through the earlier, NOAA-supported laboratory program, and was part of the *Cape May* test program. Laboratory experiments, largely conducted using Chesapeake Bay water between 1997 and 2001 indicated that, for a broad range of organisms, complete or substantial toxicity could be achieved at doses between 0.2-1.0mg/L. Test organisms included bivalve larvae, copepod crustaceans, larval fish, algae, dinoflagellates (including encysted forms) and specific bacteria such as *E. coli* and *Vibrio fischeri.* Experiments conducted in freshwater at the Great Lakes Research Laboratory, Ann Arbor, MI demonstrated that the presence of heavy sediment loads resulted in no significant change in Seakleen toxicity to the amphipod crustacean, *Hyallela azteca*. This probably reflected the low affinity of Seakleen and similar compounds for suspended particulates. Shipboard studies indicated that, under summer (2001) Chesapeake Bay conditions, a Seakleen® dose of 2.0 mg/L was more realistic in achieving a complete zooplankton kill. Phytoplankton growth potential measurements employing Chlorophyll a indicated that, under shipboard conditions, phytoplankton could be controlled at much lower Seakleen® doses; less than 1.0mg/L.

The effective shipboard Seakleen® dose (2 mg/L) turned out to be much lower than that discovered for the other biocide tested aboard the *Cape May*, Peraclean Ocean® (principal active ingredient, peracetic acid). Peraclean Ocean® proved effective in controlling zooplankton at a concentration of 100mg/L and higher. However, small-scale laboratory experiments indicated that Peraclean Ocean® had some corrosivity to steel in this concentration range. In similar tests Seakleen® appeared to be no more corrosive than undosed estuarine water.

Shipboard experiments with Seakleen® in Baltimore Harbor were conducted under an experimental discharge permit issued by the Maryland Department of the Environment. This permit allowed the discharge of Seakleen®-treated ballast water into the inner harbor under certain conditions. As part of the discharge requirements, 48h acute toxicity bioassays were conducted on Seakleen®-treated ballast water that was held aboard the vessel for a further two days beyond the 48h test period. Results of these

bioassays showed no significant residual Seakleen® toxicity to three standard test species, *Cyprinodon variegatus*, *Palaemonetes pugio* and *Mysidopsis americana*. In such cases where residual toxicity may be found, the permit still allowed Seakleen® discharge following mitigation by dilution with ambient harbor water.

The use of Seakleen®, as with any biocide was considered completely scalable. Unlike UV irradiation and filtration, there would be no restrictions with respect to the treatment flow rate. Dosers can be constructed for a few thousand dollars.

Seakleen® was considered very safe to handle, as illustrated by its extensive clinical use. Its active ingredient, menadione, vitamin K3, is a natural plant product used in livestock and fish feed, skin care creams and as a component of mouthwash. Its use as a vitamin supplement and blood clotting factor for humans, including newborn infants, contributes to its large-scale production and low current market price. At current prices, it would be anticipated that ballast water treatment would cost approximately 15cents per metric ton with very low or non-existent initial capital costs. This cost would be expected to fall significantly as production/application increased.